

WHAT IS CLAIMED IS:

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- 1 1. A hydrogen combustion heater comprising:
2 a passage for allowing hydrogen gas and air to flow
3 therethrough;
4 a first catalyst provided in said passage, said first
5 catalyst being heated, when electricity is applied thereto,
6 thereby starting a first combustion of a first mixture of said
7 hydrogen gas and said air in said first catalyst; and
8 a heat exchanger provided downstream of said first
9 catalyst in said passage, said heat exchanger being adapted to
10 transfer heat generated by said first combustion to a heating
11 medium of said heat exchanger.
 - 1 2. A hydrogen combustion heater according to claim 1,
2 wherein said first combustion is limited to a mild oxidation
3 that is defined as being free from firing of said hydrogen gas.
 - 1 3. A hydrogen combustion heater according to claim 2,
2 wherein said first combustion is limited to said mild oxidation
3 by controlling a flow rate ratio of said air to said hydrogen gas.
 - 1 4. A hydrogen combustion heater according to claim 3,
2 wherein said flow rate ratio is controlled to be greater than 8:1.
 - 1 5. A hydrogen combustion heater according to claim 4,
2 wherein said flow rate ratio is controlled to be about 15.3:1.
 - 1 6. A hydrogen combustion heater according to claim 1,
2 further comprising a second catalyst provided between said
3 first catalyst and said heat exchanger in said passage, said
4 second catalyst allowing a second combustion of a second
5 mixture of said hydrogen gas and said air in said second

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6 catalyst, when said second catalyst is heated by said first
7 combustion.

1 7. A hydrogen combustion heater according to claim 6,
2 wherein said second combustion is limited to a mild oxidation
3 that is defined as being free from firing of said hydrogen gas.

1 8. A hydrogen combustion heater according to claim 6,
2 wherein temperatures of said first and second catalysts during
3 said first and second combustions are each limited to 500°C or
4 lower.

1 9. A hydrogen combustion heater according to claim 1,
2 wherein said first catalyst comprises:

3 a first electrode;
4 a corrugated sheet wound around and electrically
5 connected to said first electrode;
6 a catalyst supported on said corrugated sheet; and
7 a second electrode electrically connected to an outer
8 portion of said corrugated sheet.

1 10. A hydrogen combustion heater according to claim 6,
2 wherein said first catalyst is smaller than said second catalyst
3 in volume,

4 wherein a first flow rate of said first mixture for
5 starting said first combustion in said first catalyst is adjusted
6 to about Q_1 defined by the following expression:

7
$$Q_1 = Q_s \times V_1 / (V_1 + V_2)$$

8 where Q_s is a flow rate of a mixture of said hydrogen gas and
9 said air under a steady state operation of said hydrogen
10 combustion heater for conducting a second combustion in said
11 first and second catalysts, V_1 is a volume of said first catalyst,
12 and V_2 is a volume of said second catalyst.

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1 11. A hydrogen combustion heater according to claim 6,
2 wherein said second catalyst is greater than said first catalyst
3 in cross-sectional area.

1 12. A hydrogen combustion heater according to claim 1,
2 further comprising a mixer for mixing together said hydrogen
3 gas and said air, said mixer being provided upstream of said
4 first catalyst in said passage.

1 13. A hydrogen combustion heater according to claim 12,
2 wherein said mixer comprises a honeycomb structure prepared
3 by winding together a flat sheet and a corrugated sheet, each of
4 said flat and corrugated sheets comprising a plurality of holes.

1 14. A hydrogen combustion heater according to claim 9,
2 wherein said first catalyst comprises at its outer portion a
3 plurality of holes.

1 15. A hydrogen combustion heater according to claim 9,
2 wherein said first catalyst comprises at its upstream portion a
3 plurality of holes.

1 16. A hydrogen combustion heater according to claim 1,
2 further comprising:
3 a blower for introducing said air into said passage; and
4 a hydrogen introducing pipe for introducing said
5 hydrogen gas into said passage, said hydrogen introducing pipe
6 comprising:
7 (a) a first hydrogen passage comprising a first valve;
8 and
9 (b) a second hydrogen passage comprising a second
10 valve,

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11 wherein, when said first valve is opened, a first flow
12 rate of said hydrogen gas is allowed, thereby starting said first
13 combustion,

14 wherein, when said first and second valves are opened,
15 a second flow rate of said hydrogen gas is allowed, thereby
16 conducting a second combustion of said hydrogen gas and said
17 air under a steady state operation of said hydrogen combustion
18 heater.

1 17. A hydrogen combustion heater according to claim 1,
2 further comprising:

3 a blower for introducing said air into said passage; and
4 a hydrogen introducing pipe for introducing said
5 hydrogen gas into said passage, said hydrogen introducing pipe
6 comprising:

7 (a) a first stop valve for stopping hydrogen flow in said
8 hydrogen introducing pipe;

9 (b) a first hydrogen passage comprising a first
10 restrictor; and

11 (c) a second hydrogen passage comprising (1) a second
12 stop valve for stopping hydrogen flow in said second hydrogen
13 passage and (2) a second restrictor,

14 wherein said first and second stop valves are each
15 operated by a working fluid that is air or an inert gas,

16 wherein, when said first stop valve is opened, said first
17 restrictor provides a first flow rate of said hydrogen gas,
18 thereby starting said first combustion,

19 wherein, when said first and second stop valves are
20 opened, a second flow of said hydrogen gas is allowed, thereby
21 conducting a second combustion of said hydrogen gas and said
22 air under a steady state operation of said hydrogen combustion
23 heater.

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1 18. A hydrogen combustion heater according to claim 1,
2 further comprising a hydrogen introducing pipe for introducing
3 said hydrogen gas into said passage, said hydrogen introducing
4 pipe comprising a discharge portion inserted in said passage,
5 said discharge portion comprising a hole for discharging said
6 hydrogen gas into said passage, said hole being directed
7 upstream of said passage.

1 19. A hydrogen combustion heater according to claim 18,
2 wherein said hole comprises at least first and second holes, and
3 said first hole is positioned at about a center of said discharge
4 portion of said hydrogen introducing pipe, and said second hole
5 is positioned between said center and an upstream end in said
6 discharge portion

1 20. A hydrogen combustion heater according to claim 18,
2 wherein said discharge portion is divided into upstream and
3 downstream halves with respect to hydrogen gas flow in said
4 discharge portion,
5 wherein said hole comprises a first hole positioned in
6 said upstream half and a second hole positioned in said
7 downstream half,
8 wherein a total opening area of said first hole is greater
9 than that of said second hole.

1 21. A hydrogen combustion heater according to claim 20,
2 wherein said discharge portion of said hydrogen introducing
3 pipe extends substantially horizontally in said passage.

1 22. A hydrogen combustion heater according to claim 20,
2 wherein said first hole comprises first holes, and said second
3 hole comprises second holes,

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4 wherein each of said first holes and said second holes is
5 substantially the same in opening size,

6 wherein said first holes in said upstream half are
7 greater in number than said second holes in said downstream
8 half.

1 23. A hydrogen combustion heater according to claim 20,
2 wherein said first hole comprises first holes, and said second
3 hole comprises second holes,

4 wherein at least a part of said first holes is greater than
5 said second holes in opening size.

1 24. A hydrogen combustion heater according to claim 18,
2 wherein said hole is directed upstream of said passage to be
3 within 45 degrees down from horizontal.

1 25. A hydrogen combustion heater according to claim 12,
2 wherein said mixer comprises first, second and third members
3 in a downstream direction of said passage,

4 wherein said first, second and third members
5 respectively comprise a first through hole of a first size, second
6 through holes of a second size and third through holes of a
7 third size, for allowing said hydrogen gas and said air to pass
8 therethrough,

9 wherein said first, second and third sizes are in
10 descending order,

11 wherein the number of said first, second and third
12 through holes are in ascending order.

1 26. A hydrogen combustion heater according to claim 1,
2 wherein said heat exchanger comprises:

3 upstream and downstream partition walls respectively
4 comprising first holes and second holes; and

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5 a plurality of pipes each extending between said first
6 hole and said second hole, each pipe having a space around
7 each pipe, said space allowing a heating medium to flow
8 therethrough.

1 27. A method for using a hydrogen combustion heater
2 according to claim 1, comprising controlling a flow rate ratio of
3 said air to said hydrogen gas, thereby limiting said first
4 combustion to a mild oxidation that is defined as being free
5 from firing of said hydrogen gas.

1 28. A method according to claim 27, wherein said flow rate
2 ratio is controlled to be greater than 8:1.

1 29. A method according to claim 27, wherein temperature of
2 said first catalyst is limited to 500°C or lower.

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